



# PRESENTATION



U.S. Department of Energy  
Solar Decathlon 2021

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Home as it was in November of 2020



## CONFRONTING BOTH LOCAL AND GLOBAL CHALLENGES

Mountain Town Housing Crisis Mountain communities are in need of sustainable ways to increase density in low-density areas. Often misunderstood as existing purely for ski vacations, mountain towns are composed of multifaceted and lively local communities with real and complex economies much like the towns that people often visit from. In recent years, however, an influx of challenges are raising housing costs beyond the reach of both low- and middle-income residents. Teachers, small business owners, restaurant staff, and seasonal resort employees are being displaced by these issues. The middle class is often considered the backbone of these mountain town economies and without them, the small businesses that contribute to the small town charm suffer.

**Currently, property and construction costs in mountain towns are high and they are on the rise.**

High investment costs and short build seasons caused by cold climates, explain why developers are choosing to focus on building luxury homes with higher return. In addition to a universal skilled labor shortage, builders and developers

are understandably selecting the most lucrative projects. Meanwhile, these second-homes often sit unused for the vast majority of the year, while the towns struggle to accommodate the heart of their community, middle-income residents and families.

### Climate Change

The climate change crisis is already here. The consequences of the world's collective inaction are making headlines consistently, highlighting both direct and indirect impacts around the globe. Among the direct include the record-breaking wildfires that destroyed 700,000 acres of land in Colorado alone just months ago, causing thousands to evacuate and entire properties to be burned to the ground. This all happened in the backyard of mountain communities that are already facing housing shortages. As an indirect consequence, the smoke from these fires extends far beyond those 700,000 acres, creating unhealthy air quality, causing respiratory issues and other dangerous health conditions for people and animals throughout the West.

Climate change has severe economic and social implications. Many fail to realize that the world's climate is deeply intertwined in various aspects of society from energy generation to tourism,

and from the food we eat to the buildings we live and work in. If we do not take appropriate action, the issues of climate change will only compound over time. The CU Boulder Team maintains a central focus to promote true sustainability. Often oversimplified, the comprehensive interpretation extends beyond environmental protection and includes two additional components: economic prosperity and social equity. With these additional components, achieving sustainability is a possibility for everyone.

### A Closer Look

In order to establish practical and effective housing solutions, the CU Boulder Team believes it's necessary to not just investigate local issues at arm's length but to dive deeper and explore the community experiences and struggles more intimately. The

reality is that housing is not one size fits all.

**The SPARC House is the product of the team's globally-minded design goals applied in a real setting with real people and real issues.**

The team's story is based in Fraser, a charming town tucked away in the Rocky Mountains of Colorado, at an elevation of 8,574 feet and with a population of just 1,378 people. By working with a client from the project's conception, the CU Boulder Team was able to better understand the unique experiences and struggles of Fraser.

With Winter Park just minutes away, Fraser attracts those who lead an active lifestyle, enjoy wildlife, and thrive on nearby ski resorts. Residents appreciate the quirky, small-town feel where



Figure 1: Fraser, Colorado

faces are familiar and everyone is seen as a valuable member of the community. Fraser embraces live music and eccentric art in the form of public murals throughout the town and weekly outdoor live music festivals, all of which further affirms a popular saying in the area to “Keep Fraser Funky.” Residents are proud of the town’s historical connection to the 1905 railroad that traversed the nearby Continental Divide (visible from

the area), connecting Denver to Salt Lake City with Fraser situated along the way. Today, an Amtrak train station located in the center of town connects Fraser to the rest of the country. While local residents appreciate the network and access that the commuter train provides, the blasting horns of the coal trains that frequently pass through at night are a constant reminder of how far we have to go to reach a clean energy

future. This is especially true for lower-income residents who often live in housing closer to the tracks. As a former competitor for the trademark “Icebox of the Nation,” Fraser possesses unique climate challenges that make it a notable location to use as precedent for designing net-zero energy, all-electric homes. Average seasonal temperatures in the US hover far above those in Fraser. Conversations with local contractors and town officials informed the team that Fraser experiences approximately three months of reliable construction conditions per year. With home and property costs rising, Fraser is experiencing the growing mountain town housing crisis firsthand, causing many to relocate and businesses to struggle to stay afloat. Those who can afford to live there are surrounded by a high and

increasing number of luxury rentals that sit unoccupied for the majority of the year. Fraser is at risk of slowly losing its livelihood as a result. The SPARC House’s build site like many other properties in the area is constricted and awkwardly shaped. The rise of property prices means lower- and middle-income families are seeking out smaller plots of land. Examining the inner workings of the town of Fraser serves as a tool for designing a house that can seamlessly integrate into the community and confront relevant and important large-scale issues affecting all mountain towns but through the unique lens of one. By speaking closely with locals and attending town hall meetings, the CU Boulder Team intentionally incorporated residents into the solution process.



Figure 2: Fraser murals are important to the character of the town



Figure 3: Train station in Fraser that connects to Denver and beyond

## CREATING THE BRAND

The CU Boulder Team’s design philosophy helps to set the tone and shape the brand. With an additional simplified, minimalistic logo option, the team is able to cohesively label all marketing materials in a professional and identifiable way. Consistent styles and a color scheme was important in setting the stage for the team’s work and outreach. The design philosophy was created on the basis of five main pillars:



Figure 4: SPARC logos

### Sustainability

The triple bottom line of sustainability was fundamental in the development of the design philosophy, and is thus the first pillar of design. The remaining four pillars are rooted in its foundation. The CU Boulder Team recognizes the importance of addressing all three principles of sustainability: economic prosperity, social equity, and environmental protection. The SPARC House strives to be effective on all three fronts by incorporating three main features into the design: an accessory dwelling unit (ADU), high performance systems and materials, and a panelized modular construction strategy.

### Performance

High energy performance is critical to reducing the home’s environmental impact and achieving the goal of attainable mountain living, which includes low operating costs for homeowners. Both passive and active design strategies have been integrated in the SPARC House in order to optimize energy performance, including strategic module placement and orientation for the site, a highly insulated structure, use of daylight and natural ventilation, passive preheat for ventilation, zone-based high efficiency HVAC equipment, and maximum power point tracking on the solar panels. The SPARC

house aims to officially expel the old myth that all-electric housing is impossible in cold climates.

### Attainability

To promote attainability, the SPARC House is designed to leverage prefabricated panelized construction methods and, with the addition of the rentable third module (ADU), bring in supplemental income to homeowners while offering more affordable rent options to service and seasonal workers than what is otherwise commonly available in mountain towns.

### Resilience

The SPARC House will demonstrate the concept of resilience in several ways, including: grid islanding capability, and a Building Automation System that can proactively control the space to an optimal electric demand profile. Climate change threatens grid reliability, with droughts reducing energy generation from hydroelectric plants, high winds and wildfires that endanger power lines, and waves of extreme temperature swings that increase space conditioning loads to levels the current electric power grid cannot sustain. With demand response functions, the SPARC House can react to signals from the utility and reduce stress on the grid when requested.

### Community

The SPARC House’s addition of the accessory dwelling unit (ADU) provides a multifaceted sustainable solution to the displacement of lower-income seasonal and year-round service workers in mountain towns. Not only does it serve as a supplemental source of income for homeowners, but it also provides viable housing opportunities for these workers at lower costs than those otherwise commonly available. Including more rentable units in residential design strengthens communities by recognizing and meeting the needs of other members. At the same time, renting and leasing fosters interaction and communication within towns, promoting the development of new relationships and unified neighborhoods. Along with creating healthier economies and an increased sense of safety, integrated communities have the capacity to improve the overall well-being of their people as stated within the United Nations 17 Sustainable Development Goals. With the adoption of the SPARC House, mountain towns will be able to showcase the power of not just sustainable housing but also sustainable communities.

# THE MAJOR OUTLETS

## Website

The CU Boulder Team's website serves as the home base for the project's outreach. There the team

can share their story and progress updates with people from all backgrounds, allowing the public to dive deeper into the project and follow whichever path sparks their interest most.



# CU BOULDER SOLAR DECATHLON

HELP OUR BUILD



### What is Solar Decathlon

The U.S. Department of Energy Solar Decathlon is a collegiate competition hosted by the U.S. Department of Energy and facilitated by the National Renewable Energy Laboratory. Consisting of ten individual contests, as illustrated below, the Solar Decathlon 2021 Build Challenge calls for students to design and build a net-zero energy, sustainable home that addresses contemporary real world needs. In doing so, students are challenged to push the boundaries of the construction industry through creativity and spark measurable and innovative solutions. The competition provides an opportunity for unique hands-on experience to better prepare students to enter the clean energy workforce as well as an unparalleled chance for the public to be educated and inspired to adopt more energy efficient measures in their lives.



Figure 5: Website pages

**THE PROBLEM**

**Mountain Town Overview**

Mountain towns represent a unique situation of economic factors, housing supply, and conditions with building new real estate. Summit County, Grand County, Pitkin County, and Eagle County account for the large majority of mountain towns. These towns built by historic mining from nearby mountain resorts cause large influxes of population from the seasonal workforce during the winter months. Summit County has one of the lowest unemployment rates in America sitting at 2.5%. Being small business owners to working hours, or shut down portions of their operations because of the lack of supply.

Homeowners are more likely to list an extra bedroom on Airbnb rather than providing support for the local community. Additionally, without subsidies or rent ceilings, seasonal workers making less than \$40,000 a year cannot afford any more. The problems for seasonal workers will only compound as the front range of Colorado continues to grow at a pace faster than the national average, causing more tourism and a need for more housing for seasonal employees.

These Colorado mountain counties are becoming some of the most expensive counties to live in, in the nation. In the recession and the housing bubble in 2007-2008, supply growth in housing slowed dramatically, then suffered a demand in recent years creating rising prices. When building began again, rather than building a variety of housing to accompany all demographics, multi-million-dollar mansions outpaced smaller entry-level homes. In Grand County, home prices are \$287,000, and the Summit County median home price is \$487,000, 2.5 times greater than the rest of the state. The average price of a single-family home in Summit County was \$731,500 (Data USA), both figures are a little higher in housing demographics.

The accelerated growth in housing prices will outpace wage growth, pricing many people out of homeownership. In order to reverse the middle-class drain and promote young families to move to mountain communities, building increased supply of entry-level homes is a must.

**THE SOLUTION**

The SPARC house is a prototype intended for real estate by addressing with modular construction, integrated systems, and the flexibility of a modular ADU. Located for the Aspen area and Frisco in Frisco, CO, a student team of four members who designed this house to be suitable for five-time homeowners, young families, and seasonal workers who struggle to find affordable housing. The SPARC house consists of three modular living units, each with its own kitchen, living, and dining area. The modular units are connected to a central core containing the bathroom, kitchen, and laundry. The house is designed to be built in a variety of locations, including mountain towns, and can be used as a primary residence or a seasonal home.

**Modularity**

The modular construction of this house is the result of our design and the advantages of modular construction including: the site, we can pre-empt any common construction issues by building the house in a factory setting. The house is designed to be built in a variety of locations, including mountain towns, and can be used as a primary residence or a seasonal home.

**Accessory Dwelling Unit**

The primary dwelling (the ADU) contains standard 800 sq ft home by providing modular for the homeowner and the secondary unit is housing for seasonal workers of mountain communities. Home owners have 3 different options to use the house:

- Option 1: Use the additional revenue to subsidize monthly housing expenses.
- Option 2: Use the additional revenue to increase the monthly mortgage payment to pay off a loan faster. Use less mortgage.
- Option 3: Use the additional revenue as a source of the overall mortgage interest, reducing the price of the home.

**26.5% Savings**

**41% Faster**

**26.5% Savings**

**THANK YOU SPONSORS AND COLLABORATORS**

We are especially grateful to Kristen Tadjirian, Joe Smyth, and our family and friends who have made this project possible!

**BECOME A SPONSOR TODAY!**

Simple Homes, beko, MITSUBISHI ELECTRIC, WAC LIGHTING Responsible Lighting, RenewAire Energy Recovery Ventilation, ACTIVE ENERGIES SOLAR, PROSOCO, Havelock Wool

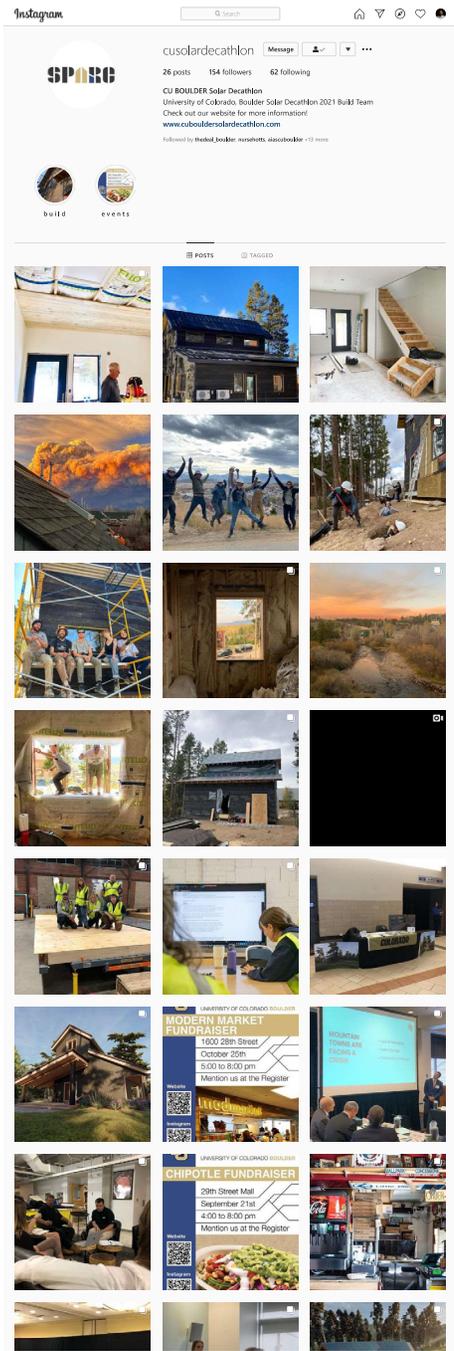


Figure 6: The CU Boulder Team's Instagram account

### Instagram

Social media has become a significant tool for marketing over the past decade. Today, content is capable of reaching millions of viewers within the matters of days by going viral. Even on a small scale, people spend hours on social media each day viewing, commenting, and sharing posts with people in their social circles. The team has used Instagram to share project progress,

fundraising opportunities, and information about climate change and how it's been affecting Colorado in recent months.

### YouTube

The CU Boulder Team's YouTube account has allowed the team to extend its reach by posting a range of video content that is both compelling and easily shareable across technology platforms. Once construction is fully complete, the team's YouTube

account will share walkthroughs of the house and other content to make viewers feel like they are there in person. Videos are an effective way to share authentic experiences and to include viewers in the construction and exhibition process in a way that allows people to access the content in their own freetime. Efficient systems and notable features of the house will be more thoroughly explained directly by members of the team in an

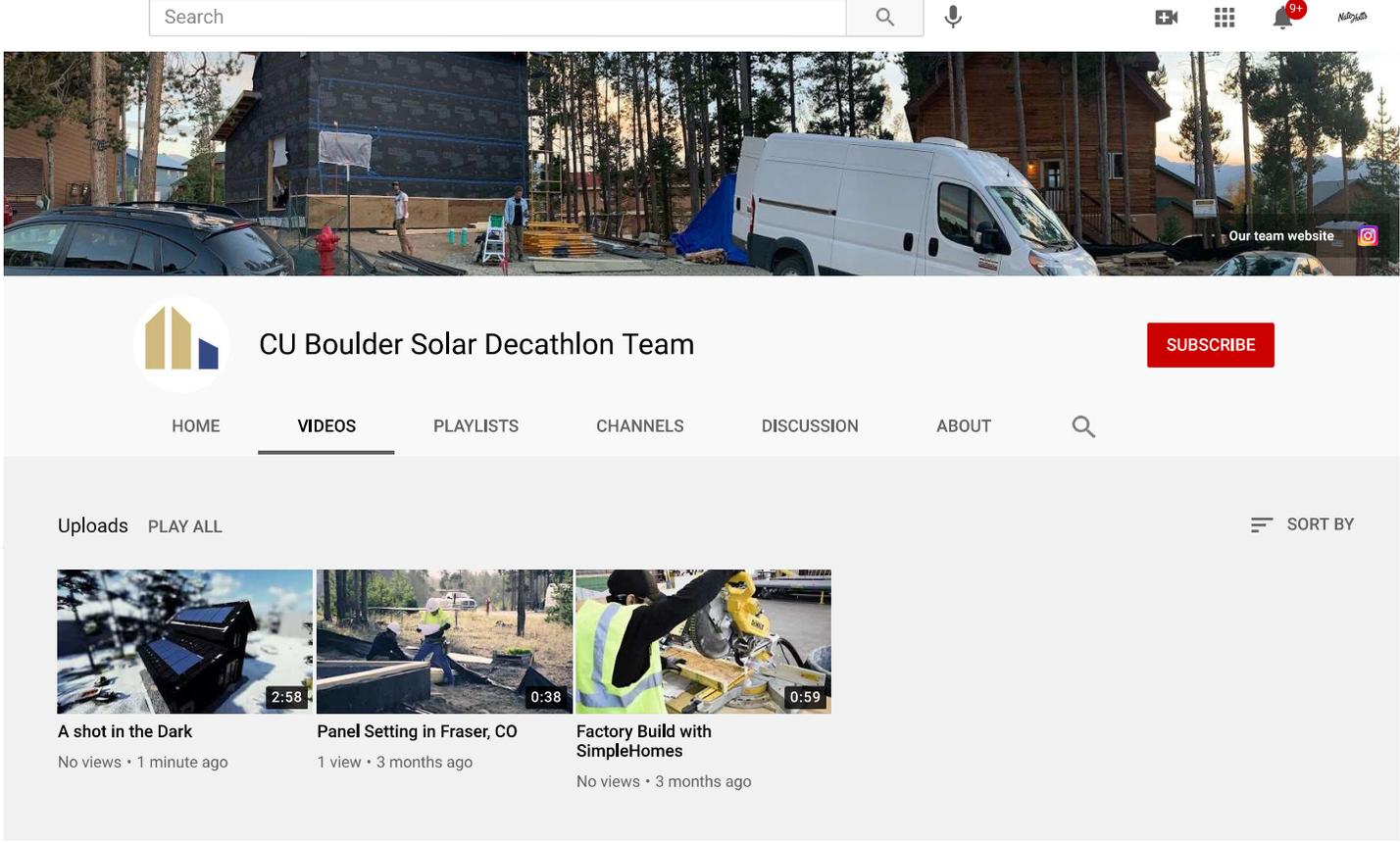


Figure 7: The CU Boulder Team's YouTube account

educational way. Construction time-lapses will showcase the team’s hard work on site. The comment section beneath each video on YouTube will allow viewers to ask questions and interact with the team in a way that doesn’t expire.

## CREATING A NETWORK

Over the course of two and a half years, the CU Boulder Team has gradually developed a network of both supporters and partners through the use of the team’s online platforms as well as other connections.

### At School

Through the University of Colorado Boulder, the team collaborated early on with the student division of the Architectural Engineering Institute (AEI) on campus to encourage participation and educate undergraduate students about net-zero home design. The team attended various club fairs and maintained a steady recruitment initiative to invite new and interested members to join at any stage of the project. Students of all backgrounds have the potential to be valuable members of the team and bring a wide variety of skill sets and perspectives to the table. The only requirement



Figure 9: Fundraising pamphlets



Figure 8: A CU Boulder Team meeting

for joining was a curiosity and interest in a challenging, real-world student-led project that would become part of a larger discussion about sustainability and the future of home design. Team leadership also presented on multiple occasions to faculty board members in order to gain interest and support for the mission on a department level. Various fundraisers were held, including one at a Denver Nuggets basketball game, which helped to spread recognition for the team. During the fall semester of 2019 and spring semester of 2020, the CU Boulder Team faculty and graduate support were able

to hold a special topics three credit course called ‘AREN 4830: Residential Design-Build I & II’, which was dedicated to understanding how to design sustainable building systems in the lens of the CU Boulder SPARC House. This allowed students to receive technical elective credits for their commitment and efforts toward the project. Other CU courses got involved at different phases of the project as well. In the spring of 2019, an Environmental Design praxis course focused on experimenting with different initial designs of the SPARC House given the context and associated design

constraints. In the fall of 2020, an Introduction to Architectural Engineering course studied the sustainable systems implemented in the SPARC House and the design process that influenced those decisions.

In the scope of younger students, the CU Boulder Team is currently in the process of organizing outreach events with K-12 students in Colorado. The team will connect with various STEM-based school clubs to talk with middle school and high school students about the SPARC house. The CU Boulder Team plans to communicate with younger students through videos as well as direct conversations to teach them about engineering applications

and opportunities.

### In the Green Building Community

The CU Boulder Team connected with a number of industry mentors to invite their expertise and learn more about how to design specific systems within the house. During the 2019 spring course 'Residential Design-Build I', the team hosted a design charrette to invite professionals from all backgrounds in the architectural engineering field to participate in a group discussion with the team about system integration in the SPARC House. The conversations centered on how to create the most efficient and comfortable living experience for the occupants and evaluating the effectiveness of the team's

designs at the time.

In November of 2019, the team attended the Urban Land Institute (ULI) Colorado event: Construction Update: How technology is transforming construction, design, and development. This event featured presentations from 4240 Architecture, Simple Homes, Kattera, etc. and allowed students to converse with and share their experiences with industry members and others involved in the green building community. By forming a partnership with Simple Homes, a modular prefabrication startup located in Denver, the team was able to enlist the help of skilled laborers, advanced production technology, and a climate-controlled factory warehouse to complete

construction of the SPARC House. The team's partnership with Simple Homes proved to be an integral element of the project and now, the SPARC House is showcased on the Simple Homes website, to be shared with their own network of clients and partners.

The team also participated in various interviews, both with more official organizations such as the Department of Energy's Solar Decathlon Blog, and with other student groups who are interested in taking on a similar project in a different scope. The CU Boulder Team's story will continue to be shared post-competition to both recount the significance of the experience and the valuable lessons learned along the way.



Figure 10: A CU Boulder ENVD class



Figure 11: The team at Design Challenge Weekend at NREL in April 2019

## In Fraser and Surrounding Mountain Towns

Sharing the team's story and developments in Fraser, Colorado, and surrounding mountain towns was integral to the project's mission. In 2018, the team visited Fraser and met with local town council and contractors in the area. It was important not only to gain an understanding of the needs and unique circumstances of residents in mountain communities, but also to involve them in the journey of the project. The team attended a town hall meeting in 2019 to speak with members about the affordable housing crisis and appeared in articles, such as one written for Sky-Hi News, which serves Grand

County in Colorado. A local radio station interviewed both the team leads and clients during the on site panel assembly in the fall of 2020. The team also attended an event hosted by the local non-profit organization Mountain Parks Electric during its campaign to encourage the public to shift to all-electric utilities. Ongoing, the SPARC House's story will live on as the ADU is rented out to residents in need. The team's contribution to the community will remain a topic of discussion as new members are able to live there and learn about the sustainable systems and intentional design features that led to the development of the house.



Figure 14: Neighbors in Fraser love to admire the SPARC House's progress and learn about the student-led team

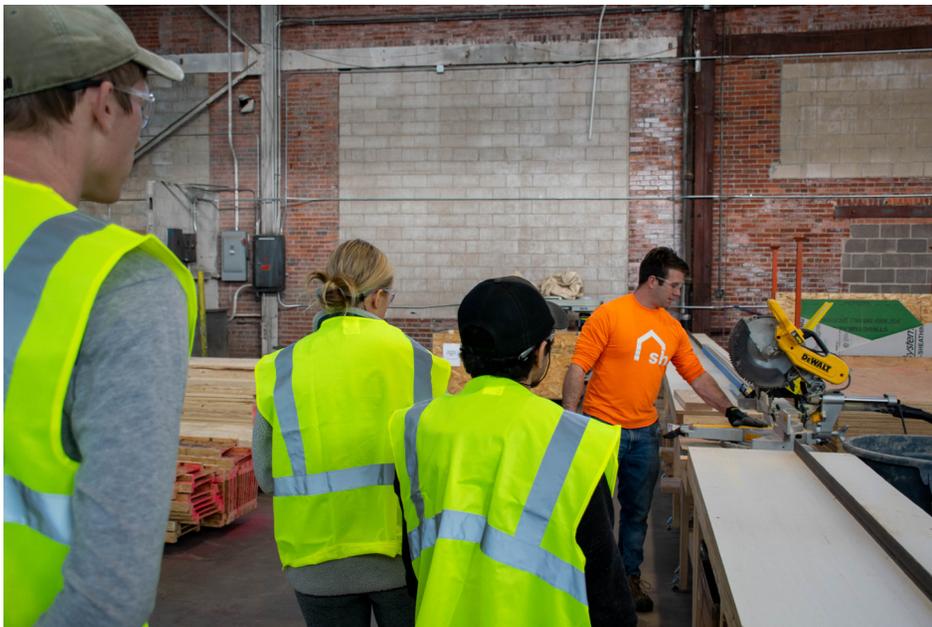


Figure 12: Getting familiar with tools and safety precautions at Simple Homes' factory



Figure 13: The team's first visit to Fraser in the fall of 2018 when they first met with their clients, a Fraser town official, and a local contractor